Mixed-Integer Formulations for Constellation Scheduling

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LDRD LABORATORY DIRECTED RESEARCH & DEVELOPMENT

Problem

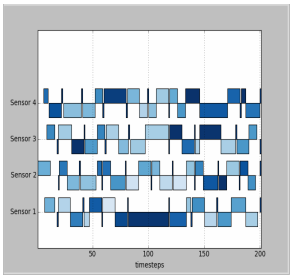
Remote sensing systems have expanded the set of capabilities critical to national security. Constellations of agile, high-fidelity sensing systems and growing mission applications have exponentially increased the set of potential schedules. Advanced scheduling tools are lacking and operators are overburdened. Nowhere is this more costly than in time-critical scheduling decisions. Assisted decision-making through identification and comparison of alternative schedules remains a challenging problem applicable across remote sensing systems.

Approach

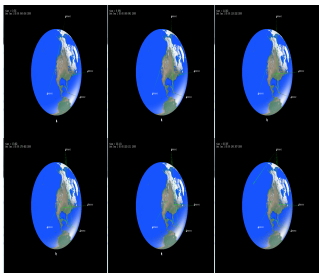
Using the *Pyomo* optimization modeling tool, we have developed software in Python and C++ that poses and solves mixed-integer models for foundational problems in scheduling constellations of remote sensors:

- Scheduling where activity demands outnumber available sensor resources
  - Optimize according various criteria:
    - Activity priority,
    - High-fidelity measures of sensor performance
  - Allow for customer tuning of criteria for acceptable activity performance
  - Create schedules that obey periodic calibration and sensor safety constraints
- Sensor stare-point (footprint) placement optimization within individual activities and across geo-spatially separate activities
  - Optimization of sub-footprint sizing and placement, according to sensor and bandwidth constraints
  - Optimization of stare-point placement according to optimal sub-footprint solutions
- Scheduling to minimize disruptions caused by adhoc activities and weather

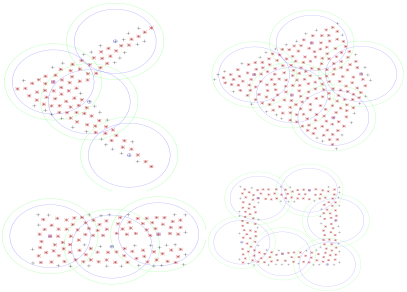
Preliminary Results



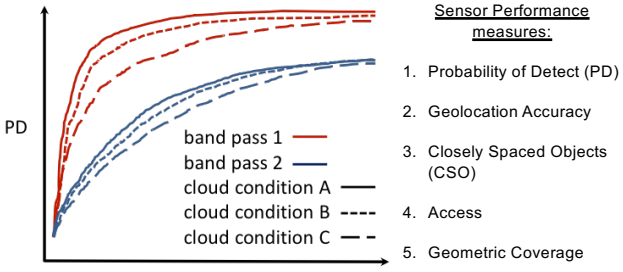
Computed four sensor schedule. Darker blues denote higher activity priority. Calibration activities are black.



Screenshots from dynamic sensor footprint visualization.



Examples of optimal (circular) footprint placements for individual activities. Footprint radius denoted in green, coverage points denoted in red.



Accessible draw band pass and cloud database Receiver Operating Characteristics (ROCs).

Significance

- Framework designed and implemented to carefully trade schedule optimality for timely decision support
- Support for arbitrary numbers of sensors and activities and variable precision time-steps
- Framework is adaptable to changing schedule objectives, adhoc activities, and periodic calibration activities
- Mixed-integer model provides access to valuable analytics

NNSA National Nuclear Security Administration
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